Water's for Fighting:
A role for the NOAA-OGP Western Water Assessment in the Colorado River Basin

RISA Speaker Series
September 12, 2005
NOAA, Silver Springs

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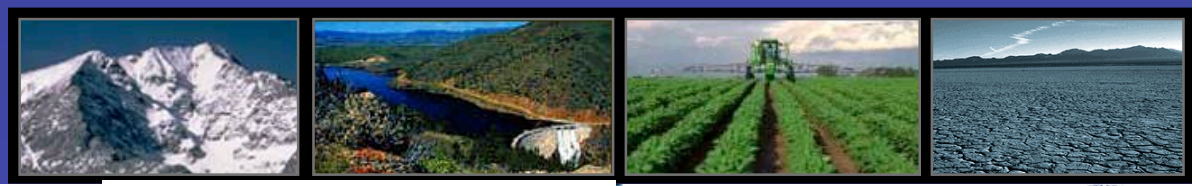

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NOAA-CIRES Climate Diagnostics Center

Cooperative Institute for Research in Environmental Sciences

CIRES Colorado
University of Colorado at Boulder

NOAA

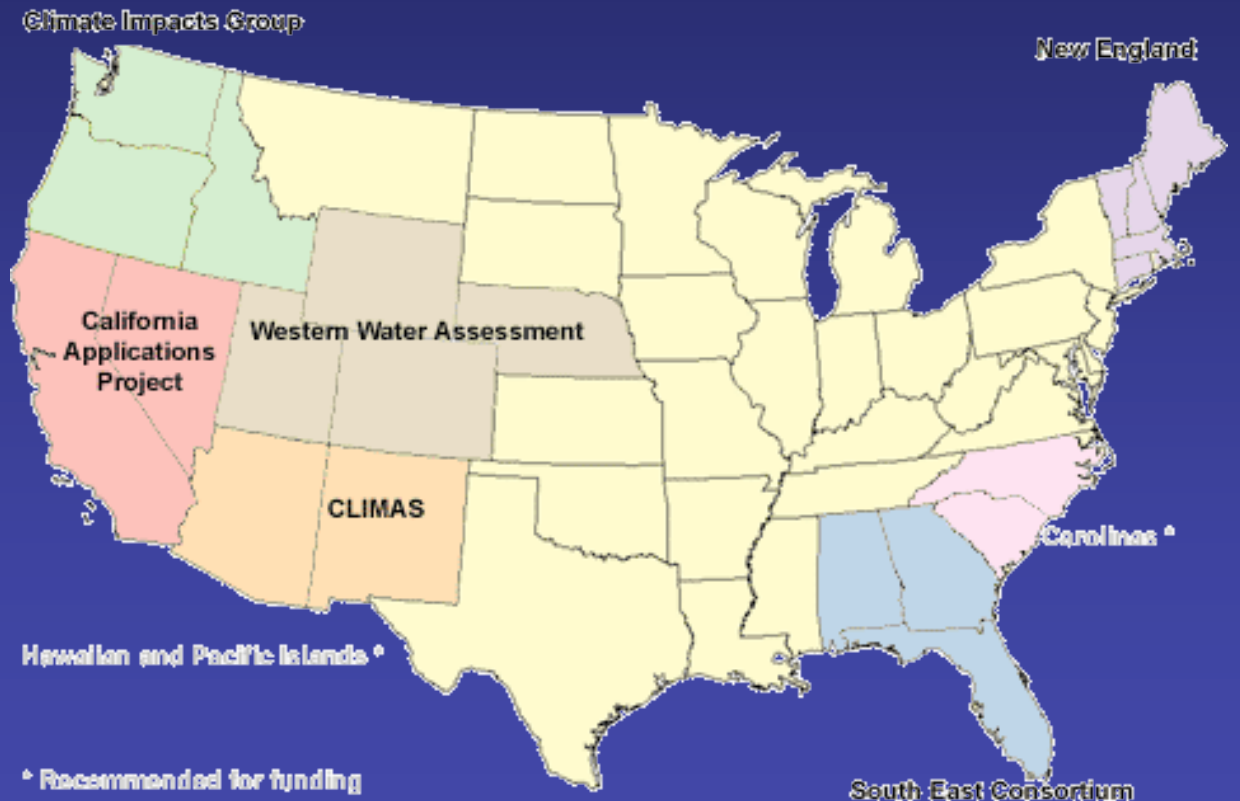
Talk Overview

- Western Water Assessment Background - Brad
  - Region and Issues
  - History
  - Mission
  - Internal Workings / Methodology
  - Projects Overview
  - Mini Case Studies (2)
  - WWA Outreach / Partnerships Overview
- Case Study: Colorado River Basin - Doug
  - Background
  - Short Term and Long-Term Problems
  - WWA Research and Decision Support
- Wrap-Up
  - WWA Take Home Lessons – Brad
- Questions – All for Doug??

"Everybody talks about the weather but nobody does anything about it."

~Another Mark Twain Quote

Western Water Assessment one of 8 Similar Regional Integrated Sciences and Assessments ("RISA") Programs.



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History

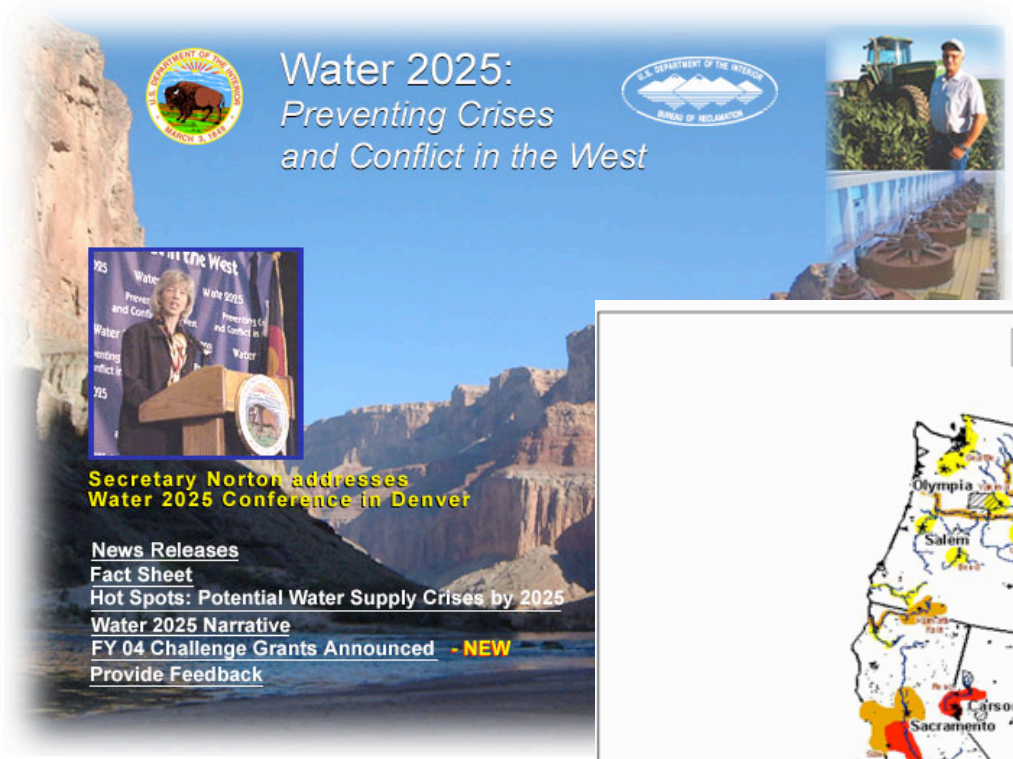
- Founded 1999, First Real Funding 2001
- 2001 Review
- Joint CU-CIRES and NOAA-CDC Effort
- CSU Officially Added 2004

Regional Setting -1

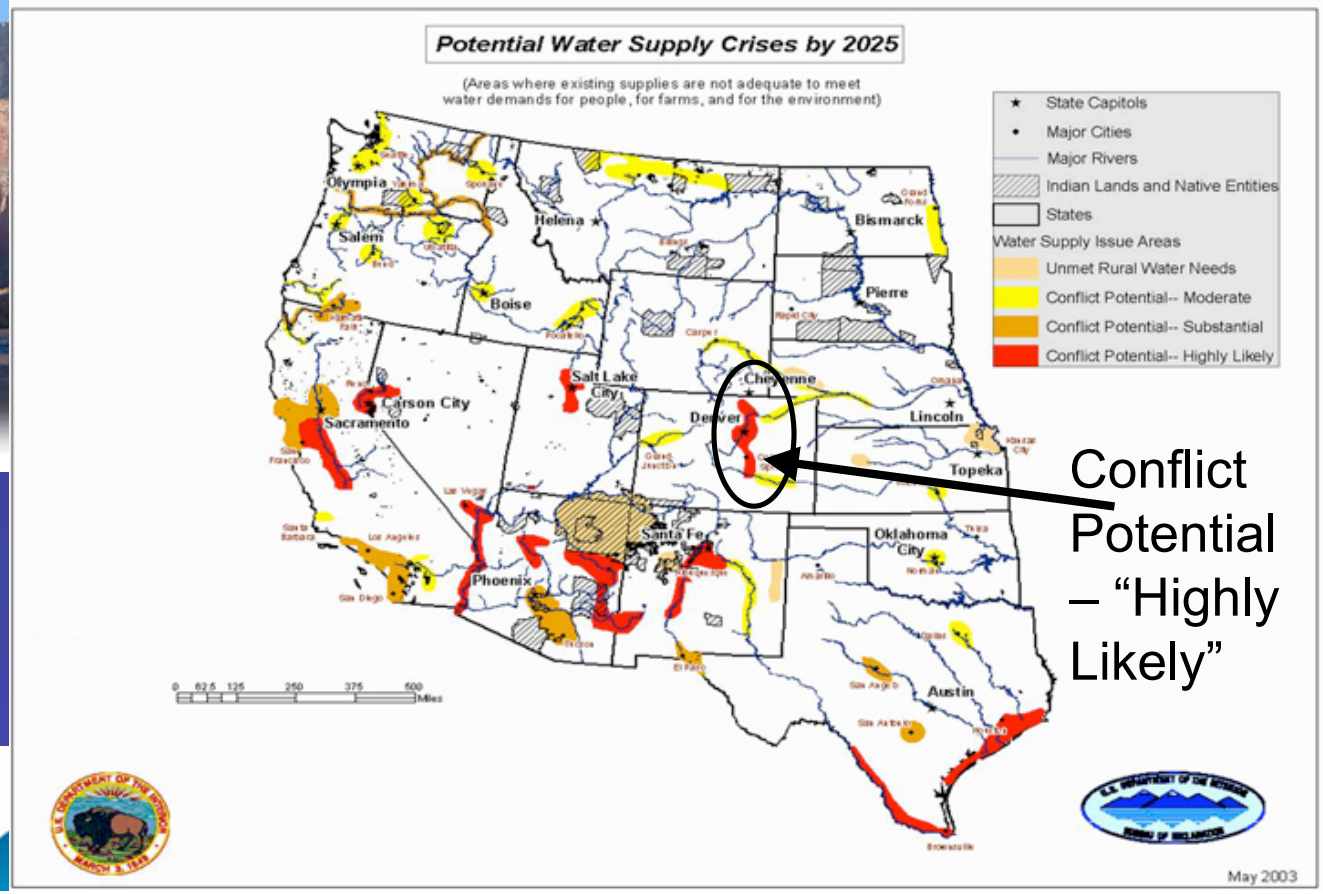
- Population Growth
- All Rivers Fully Appropriated except for Colorado River
  - Colorado River may have from 0 to 1 maf left near Utah
- Arid and Wet – Denver at 14” /year, Mountains at ~ 40”
- Endangered Species on Most Rivers
- Complex Legal Environment – State, Federal Laws, Courts
- Multiple Layers of Government, with USBR big player
- Ag has over 80% of supplies
- Historically no statewide planning
- Increasing recreational component
- History of contentious disputes over water, e.g. transmountain

Regional Setting -2

"Water is the lifeblood of the American West and the foundation of its economy" (Water 2025)



"Existing water supplies are, or will be inadequate to meet the water demands of people, cities, farms, and the environment"



Conflict Potential – "Highly Likely"

Underlying assumption of a statistically stationary

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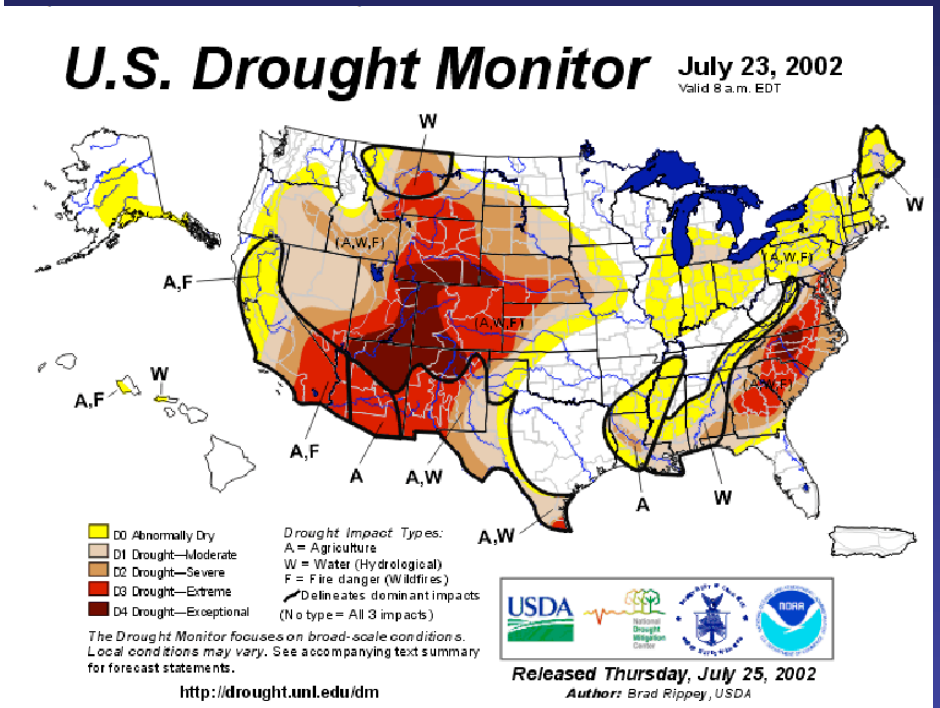
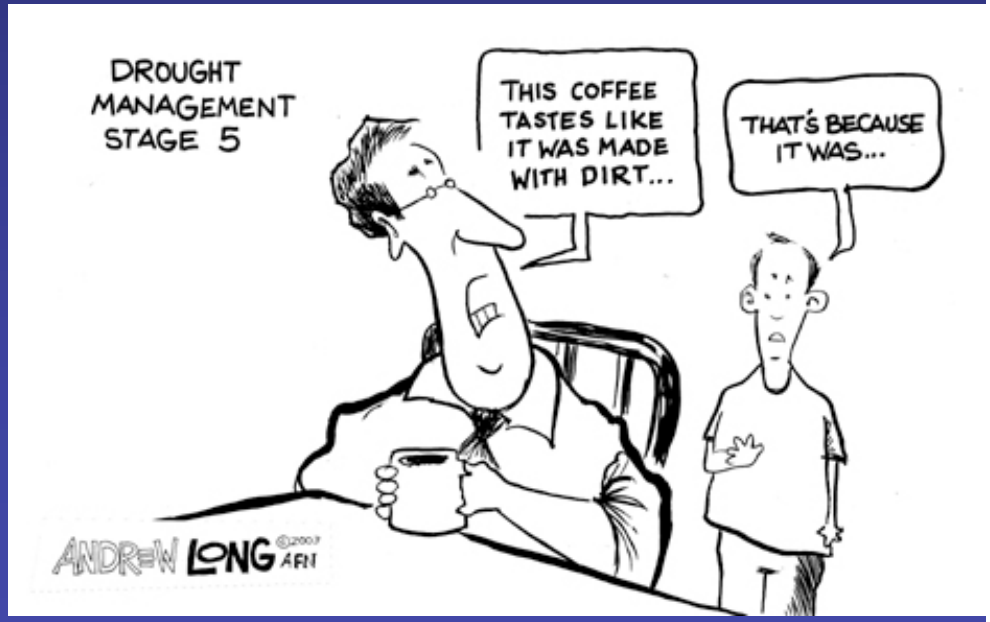
Regional Setting 4 - Climate Variability: Summer 2002





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What is the Mission of Western Water Assessment?

Two Missions: 1 “External” and 1 “Internal”

External Mission:

Identify and characterize regional vulnerabilities to climate variability and change,

....and,

Develop information, products and processes to assist water-resource decision-makers throughout the Intermountain West.

What is the Mission of Western Water Assessment?

Internal Mission:

Help NOAA Consider and Implement Future "Climate Services", a complement to the National Weather Service but Different…

Both Missions are shared with **everyone.**

Sample Existing WWA - NOAA Connections

River Forecast Centers – Streamflow Forecasts
Climate Prediction Center – Forecast Input
Regional Climate Focal Points – Meetings, Intermountain Summary
Climate Services Division – Meetings, Clearinghouse, New Climate Divisions
National Drought Mitigation Center – NIDIS, Economic Studies
Regional Climate Centers – Data Use, Kelly Redmond

Intersection of WWA's and NOAA's Missions

NOAA's Matching Strategic Goals:

- **Mission Goal 2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.**
- **Mission Goal 3: Serve Society's Needs for Weather and Water Information.**
- **Cross-Cutting Priority 3. Promote Environmental Literacy**
- **Cross-Cutting Priority 4. Ensure Sound, State-of-the-art Research.**

Who is WWA ?

Integration

Core – Brad Udall, Roger Pulwarty, Doug Kenney

University of Colorado Scientists

Legal and Policy – Doug Kenney, Bobbie Klein, Roger Pielke, Jr.
Snow and Hydrology – Martyn Clark, Balaji Rajagopalan
Water Quality – Jim Saunders
Economics – Chuck Howe, Chris Goemans

NOAA-CIRES Climate Diagnostics Center Scientists

Policy – Andrea Ray, Roger Pulwarty, Jessica Lowrey
Climatologists – Klaus Wolter
Snow Scientists – Shaleen Jain, Jessica Lundquist
Paleoclimatologists – Connie Woodhouse, Robin Webb, Jeff Lukas

Colorado State University Scientists

John MacKenzie, Reagan Waskom, Dan Smith, John Wilkin-Wells

Principal Investigators – Susan Avery, Randy Dole

2003 Western Water "Re-"Assessment

Internal and External Scan (October and November)

1) 2001 External Review
2) NOAA Strategic Plan
3) Climate Change Strategic Plan
4) RISA Vision Document
5) PI Statements of Accomplishments/ Team Survey

Guiding Document (December)

1) Mission Statement
2) Research Objectives
3) Proposal Timeline
4) Guidelines for Projects
5) Proposal Process and Selection Criteria

Proposals (January)

1) 2-Page "Draft-Drafts"
2) 10-Minute Team Presentations
3) 2-Page Drafts
4) Comments by Core and Management Team
5) Final Submissions w/ 2 new pages addressing comments

Funding Decisions (February 2004)

Funding Based on:

Merit
Budget
Response

"The beatings will continue until morale improves….."

WWA Activity Matrix…

Evaluation Matrix 1 for WWA Activities		RISA Means, Current					
		Links to Decision Makers	Links to NOAA Operations	Integrated Research	Synthesis Research	Self Evaluation	Training New Leaders
RISA Ends	Assessments						
	Information, Products & Processes						

Evaluation Matrix 2 for WWA Activities		Temporal Scale			
		Paleo	Seasonal to Interannual	Decadal	Global Change
RISA Ends	Assessments				
	Information, Products & Processes				

Sample Stakeholder Research Partners

- Municipal
  - Denver Water Department
  - Aurora Utilities
- Combined Ag and M&I
  - Northern Colorado Water Conservancy District
- Federal
  - United States Bureau of Reclamation
- Non-governmental
  - Ditch and Reservoir Company Alliance
- State Chartered Planning Entities
  - Colorado River Water Conservation District
  - Colorado Water Conservation Board

Not all stakeholders are alike.

Some Current Major Projects…

South Platte Regional Assessment Tool

Streamflow Reconstructions using Tree-Rings

Climate Services Clearinghouse

Improved “Week 2” Streamflow Forecasts

Experimental Seasonal Forecasts for Drought Task Force**

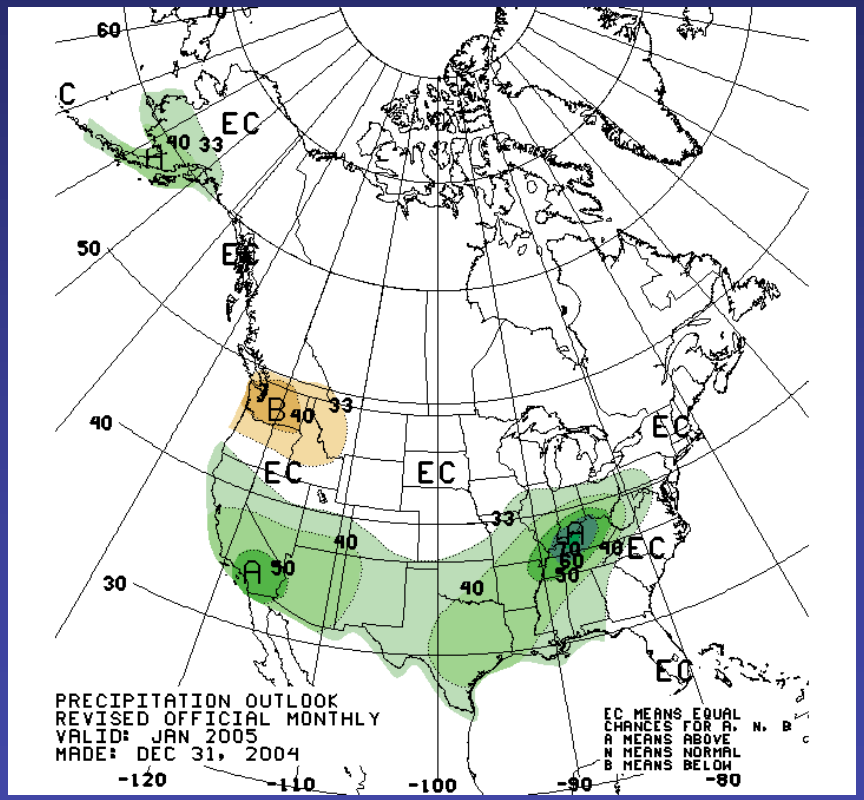
Use of Climate Forecasts by Ag – CSU**

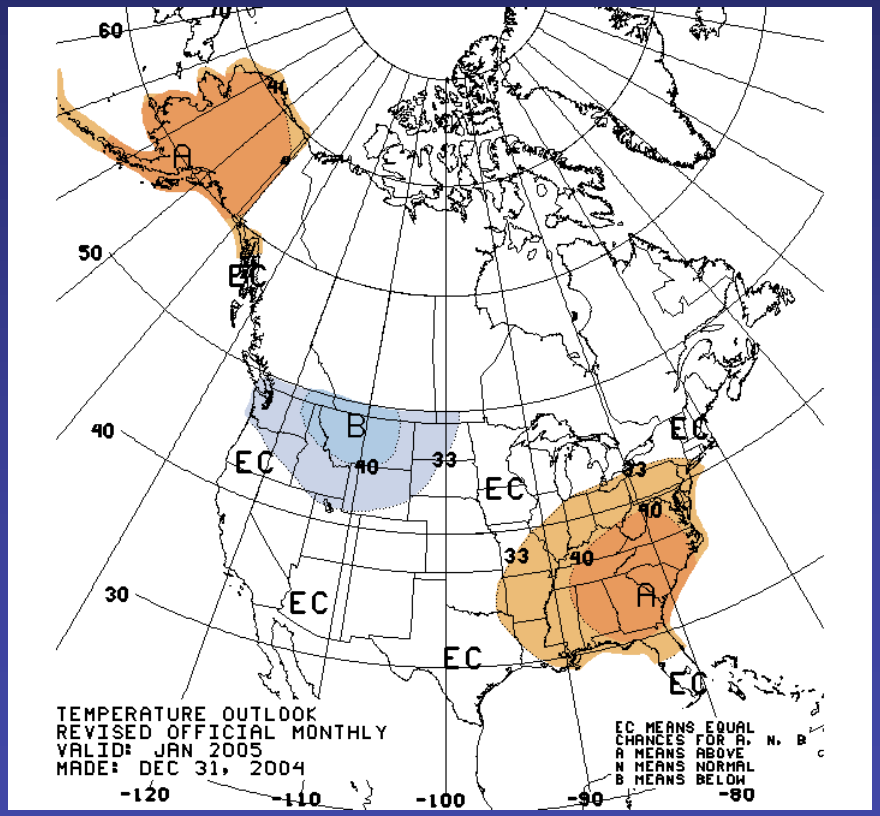
Intermountain West Climate Summary**

Front Range Municipality Large User Study

Colorado River Decision Support Activities

Mini Case Study 1: Background Regional Experimental Forecasts





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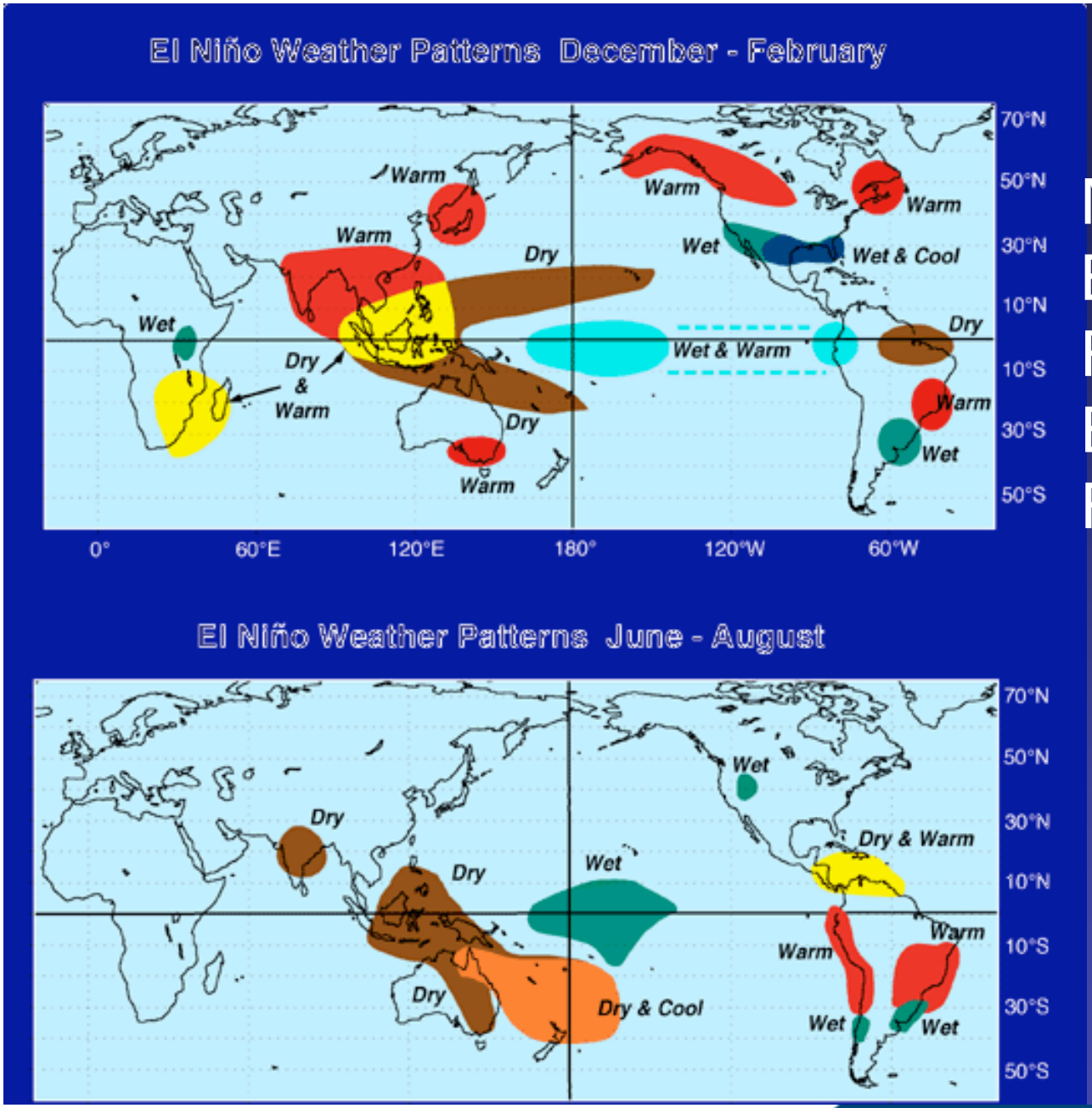

Mini Case Study 1: Background Regional Experimental Forecasts

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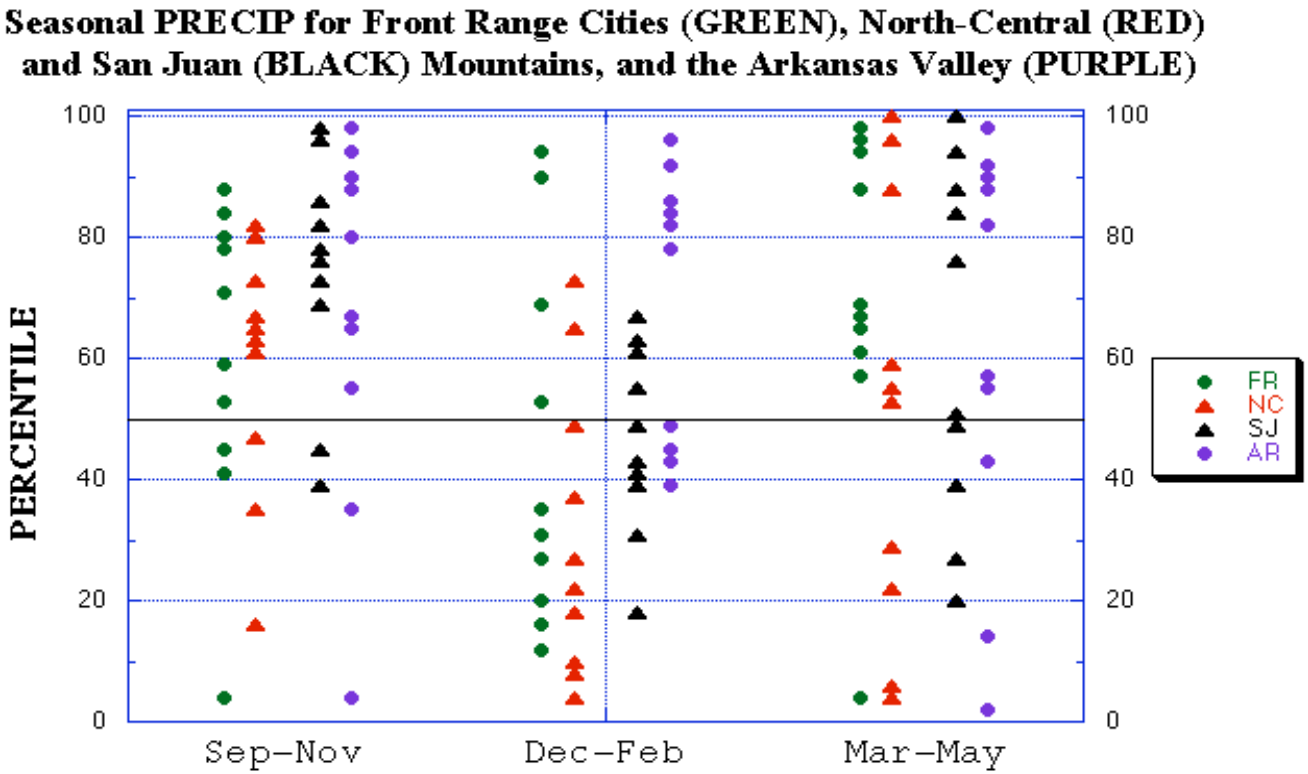
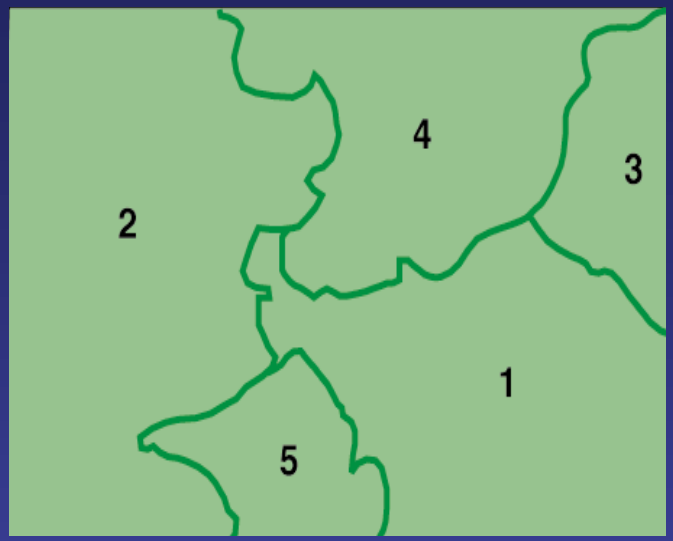
Mini Case Study 1: Regional Experimental Forecasts



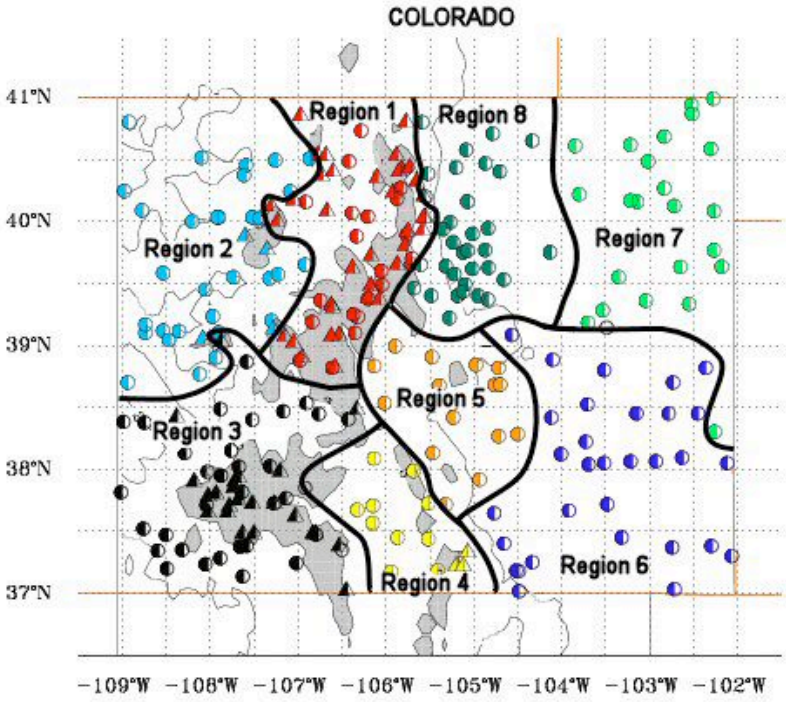
Source: Wolter Website, 2004

http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/index.html

Focus on Climate Divisions (CDs)



Official CDs for Colorado (left) and Experimental CDs (right) based on multivariate statistical analysis of climate data that also include **SNOTEL** data. Such new CDs are being derived for entire U.S.



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Mini Case Study 1: Regional Experimental Forecasts

Colorado (and Interior Southwest) forecasts - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

Address http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/ Go

Links

Google wolter forecast Search Web 1316 blocked AutoFill Options wolter forecast

Colorado (and Interior Southwest) forecasts

- 1. Current status of the El Niño/Southern Oscillation (ENSO) phenomenon and prospects for the next six to ni
- 2. Regional climate variability and El Niño composites
- 3. Most recent Climate Prediction Center forecasts for February through June 2005
- 4. Most recent experimental forecasts for January through June 2005
- 5. Discussion of forecasts
- 6. Executive summary

Outline for latest forecast webpage (updated on Janua February 24th, 2005)

This webpage consists of six parts:

1. Status and Outlook for ENSO (El Niño/Southern Oscillation), the most important global climate variability factor

6. Executive summary (updated on January

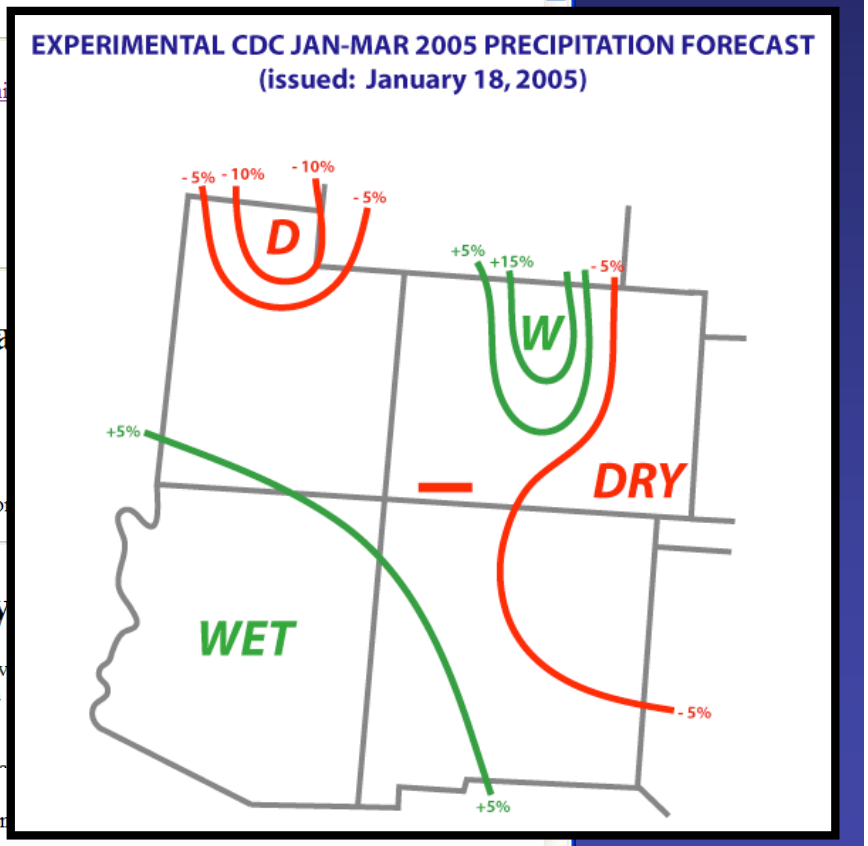
1. The 2004-05 El Niño event continues to limp along, with large-scale SST anomalies that barely exceed 1C (2F). Nev precipitation anomalies have been consistent with typical El Niño-associations (for instance, a failed summer monsoon in the southwestern (northwestern) U.S.).

6. Executive summary of this webpage: half of Colorado (western Colorado only caught up in the fall), our snowpa

The most recent forecasts are based on data through December 2004. This website will remain online until further n

You are welcome to use any of the material from this website, but proper acknowledgment would be appreciated, especially when referring to figures, forecasts, and

Internet



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Mini Case Study 1: Lessons

- CPC Forecasts lacked spatial scale needed by Colorado water managers.
- 2002 Drought prompted interest and attention.
- Task Force is opportunity to interact with State Engineer, State Climatologist, NWS Local Forecast Office, Economic Sectors, NRCS Snow Staff, Media
- Wolter an active participant with CPC, provides feedback into operations
- Existing Climate Divisions poor for WWA prediction needs; research on new divisions underway.

CSU Activities

- CSU is the Land Grant College in the State
- Expertise both in Water and in Agriculture, Extension
- WWA Approached CSU in late 2003
- Worked through Colorado Water Resources Research Institute and Extension
- Current Project is with the Water Sociology Lab
  - Micro Watershed Forecasting
- Use of climate information by small-scale agricultural water systems, with particular attention to ditch 'quotas'

- Also, Of Note:
  - Long time relationship with State Climatologist's office
  - University of Nebraska – economic impacts of drought

WWA Outreach Activities, AKA "Climate Affairs"

- Sample Invited Talks
  - Denver Water Planning Group
  - Colorado River Water Conservation District Annual Colorado Water Workshop
  - Northern Colorado Water Conservancy District
  - Western Governors' Association
- Power to Convene
  - Denver Water
  - Aurora Utilities
- Web Presence
- Opinion Pieces
- TV & Radio Interviews
- Intermountain Climate Summary
- Drought Task Force Attendance
- Sponsorship of NRLC Conferences
- Publications , e.g, Water and Growth, Water and Climate

Case Study: Intermountain Climate Summary

INTERMOUNTAIN WEST CLIMATE SUMMARY

by The Western Water Assessment — Issued May 11, 2005

May 2005 Climate Summary

Hydrological Drought – Hydrological drought continues in much of the West even though many areas have Standardized Precipitation Indices in the normal or above normal range. This is because several years of below normal precipitation have depleted

In This Issue

Seasonal Forecasting: Skill in the Intermountain West?

By Brad Udall, director of the Western Water Assessment; and Martin Hoerling, meteorologist at the NOAA Climate Diagnostics Center.

People have long been interested in outlooks of climate, as shown by the popularity of the Farmer's Almanac for over two centuries. More recently, climate scientists have been producing official climate forecasts on a regular basis. This article describes what seasonal forecasts are, the scientific basis for making forecasts, and the skill of these forecasts over the U.S. West.

A seasonal climate forecast is about the average conditions over a future period of time, rather than a prediction for a particular day. (The latter is commonly called a weather forecast.) In addition, a seasonal climate forecast is a prediction of the departure from the normal march of the seasons. So, saying that summer comes after winter is hardly a seasonal forecast! What we really wish to know is also provide valuable clues to the future.

The memory of climate conditions can influence the future seasonal state of the atmosphere, and leave a definable and predictable signal. Climate memory is most prevalent in the world oceans, where cool or warm anomalies in the sea surface can take months, and sometimes years, to revert to normal. Unusual land surface conditions, such as excess spring soil moisture accumulated from heavy rains or deep early winter snow cover, may also provide memory. Climatologists have only recently fully understood the "granddaddy" of these signals, an irregular prolonged warming (or cooling) of the tropical Pacific Ocean, known as El Niño (or La Niña) or collectively as the El Nino/Southern Oscillation (ENSO). In the late 20th century, climate scientists were

each month based on dynamical and statistical forecasting techniques. CPC issues forecasts for three-month periods with lead times ranging from 0.5 to 12.5 months. For example, in mid-May, CPC will issue temperature and precipitation forecasts for June-July-August (0.5 month lead), July-August-September (1.5 month lead) and all subsequent forecasts up to June-July-August of 2006 (12.5 month lead). These forecasts rely primarily upon two critical climate processes: (1) the status of ENSO and (2) long-term upward temperature trends, which climatologists have been observing for the past several decades. In the Western U.S. especially, this trend is pronounced (see Figure 1a).

How do we assess these forecasts? There are two standard measures to assess the performance of forecasts, ac-

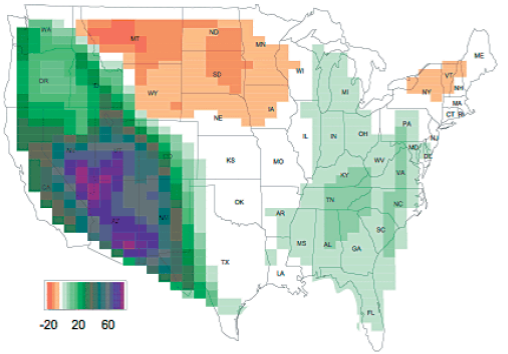

Figure 1c: Skill scores for February to June temperature during non-ENSO events, predicted at 0.5 to 12.5 months in advance. Note the strong skill in the western United States.

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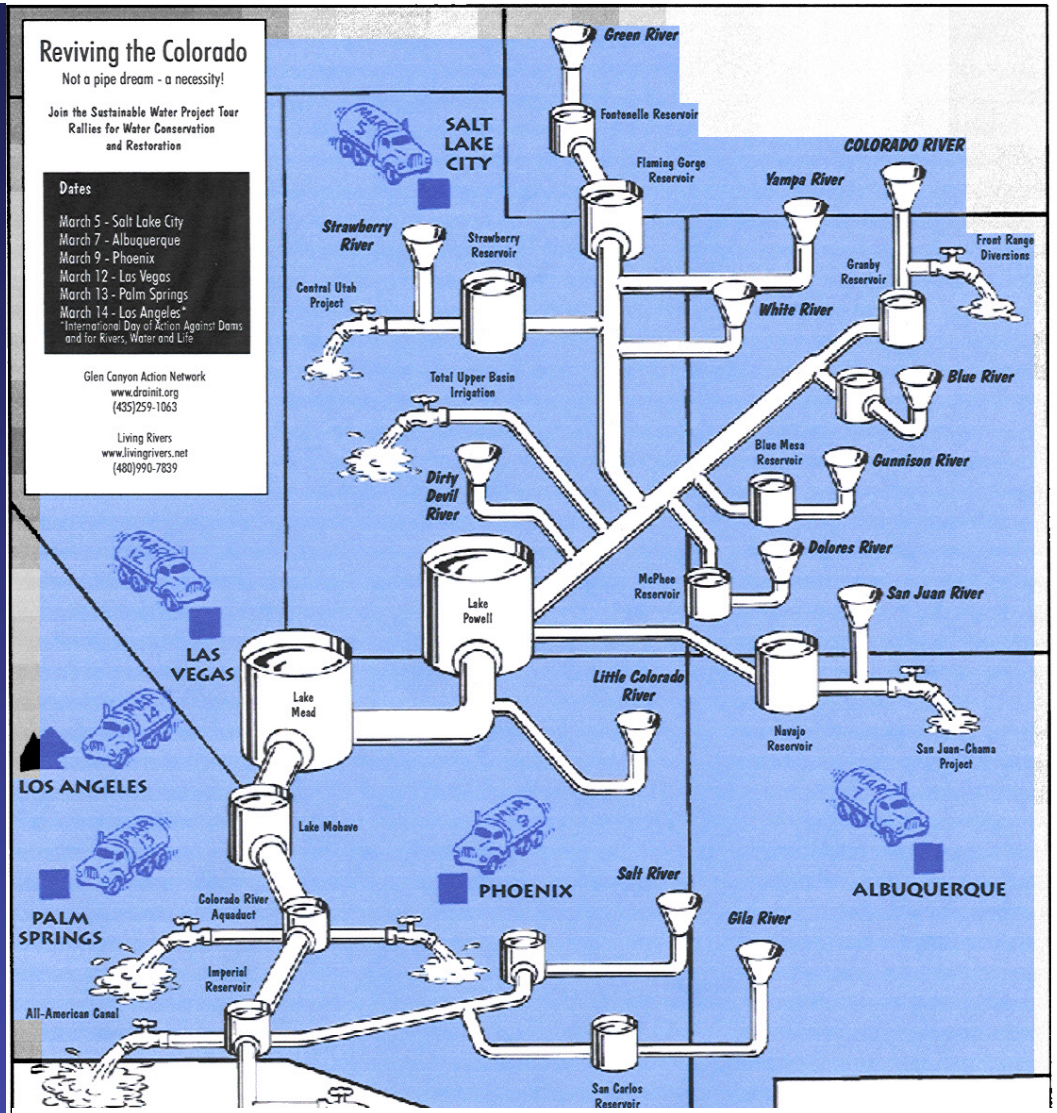
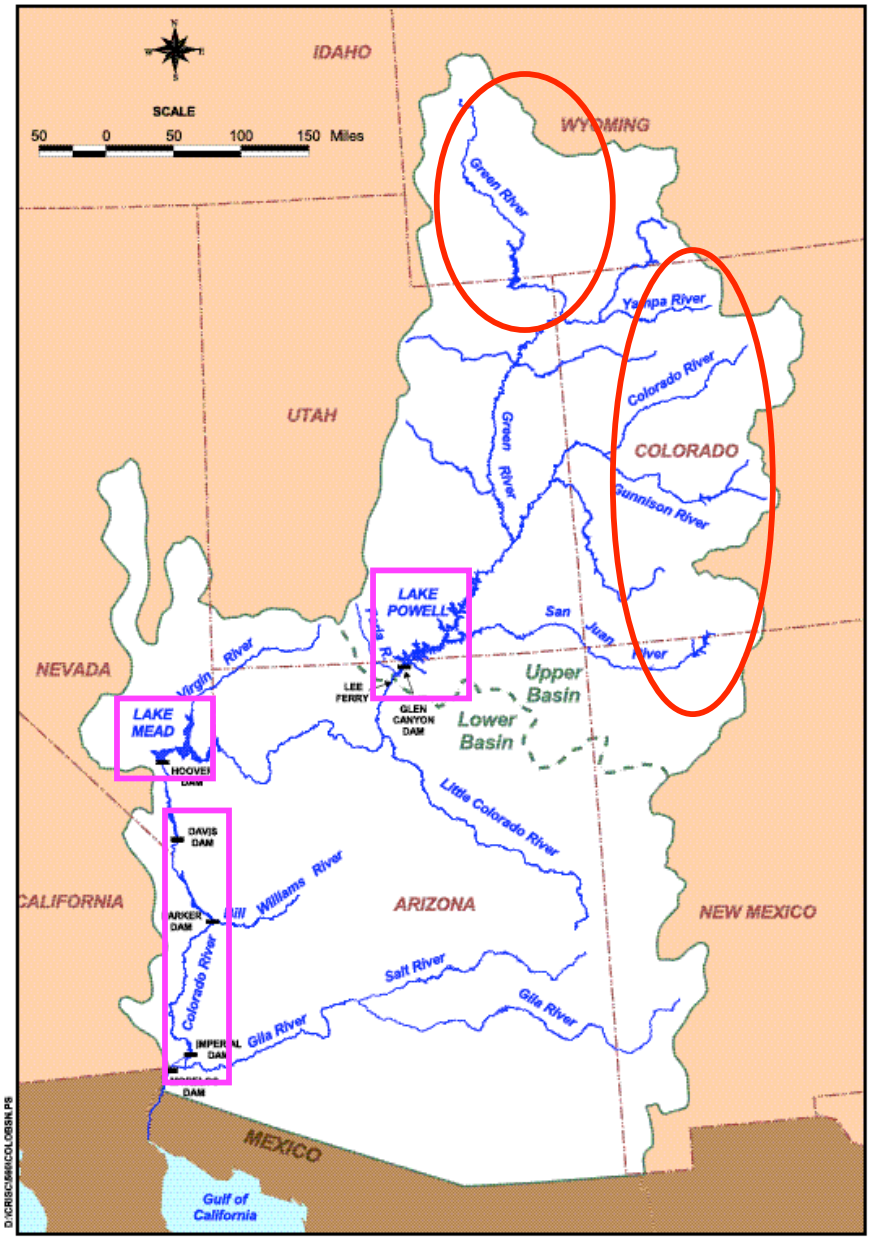
Case Study: Colorado River Basin



One View of the Colorado River…



Colorado River

- Snowmelt-dominated system
- Heavily developed
- Water for 25+ million
- Extremely complex legal and political framework
- Fastest growing region
- Potential Train Wreck – both short-term and long-term

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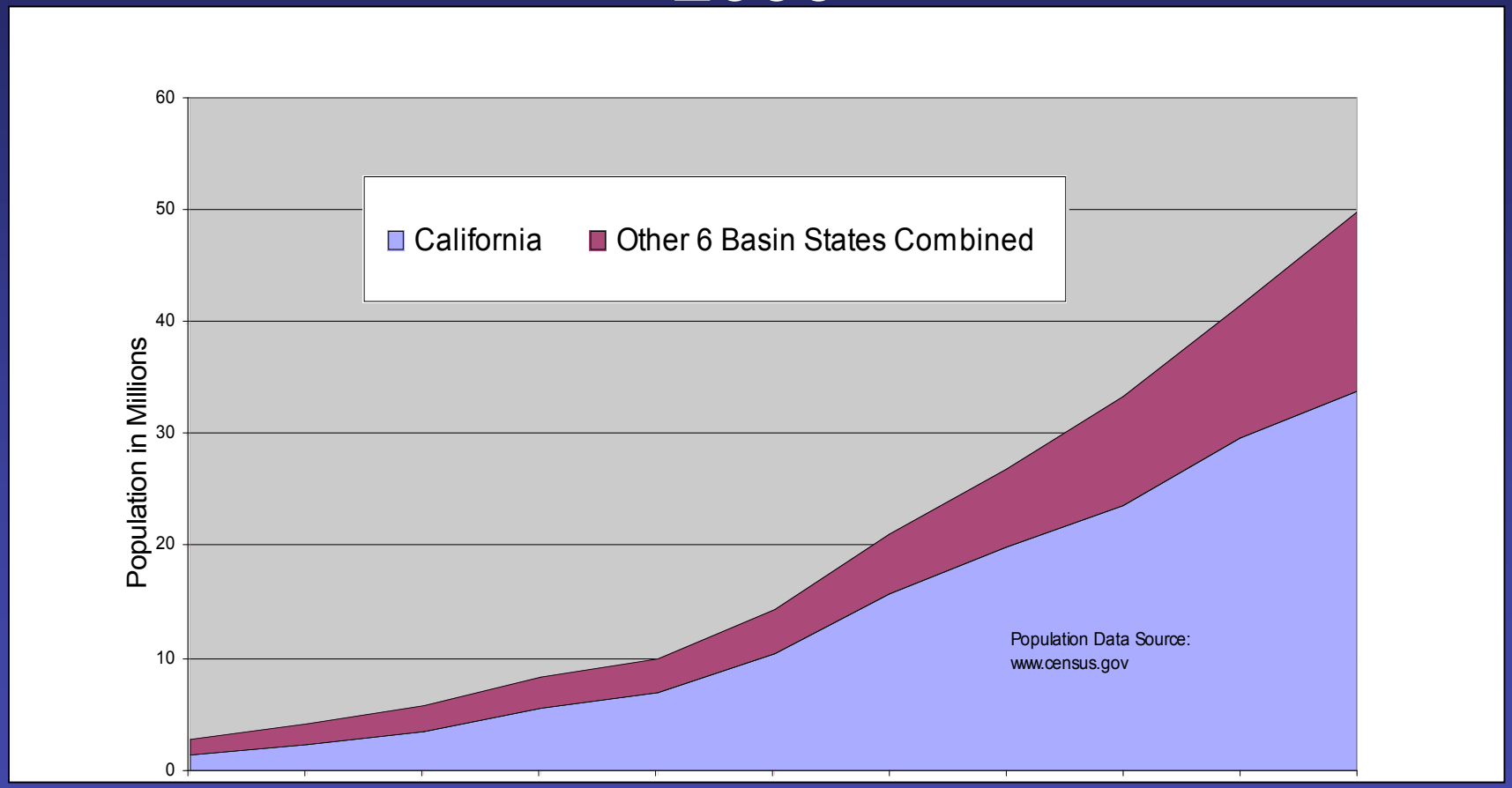
Key Elements of Law of the River

- Allocation rules:
  - Two interstate compacts (1922, 1948)
  - Treaty with Mexico (1944)
  - Decades-long Supreme Court case (*Arizona v. California*, 1963)
- Several major water development acts (e.g., 1956, 1968)
- Sophisticated reservoir operations rules

Basin States Negotiating Teams

Population Growth in the Colorado River Basin: 1900 – 2000



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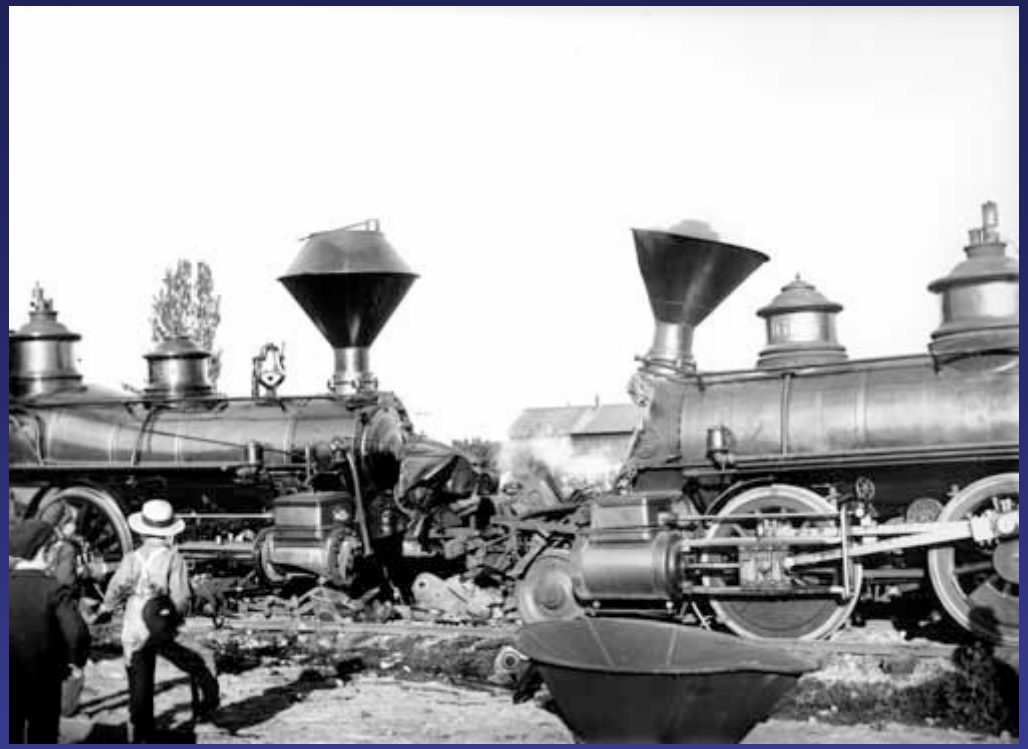
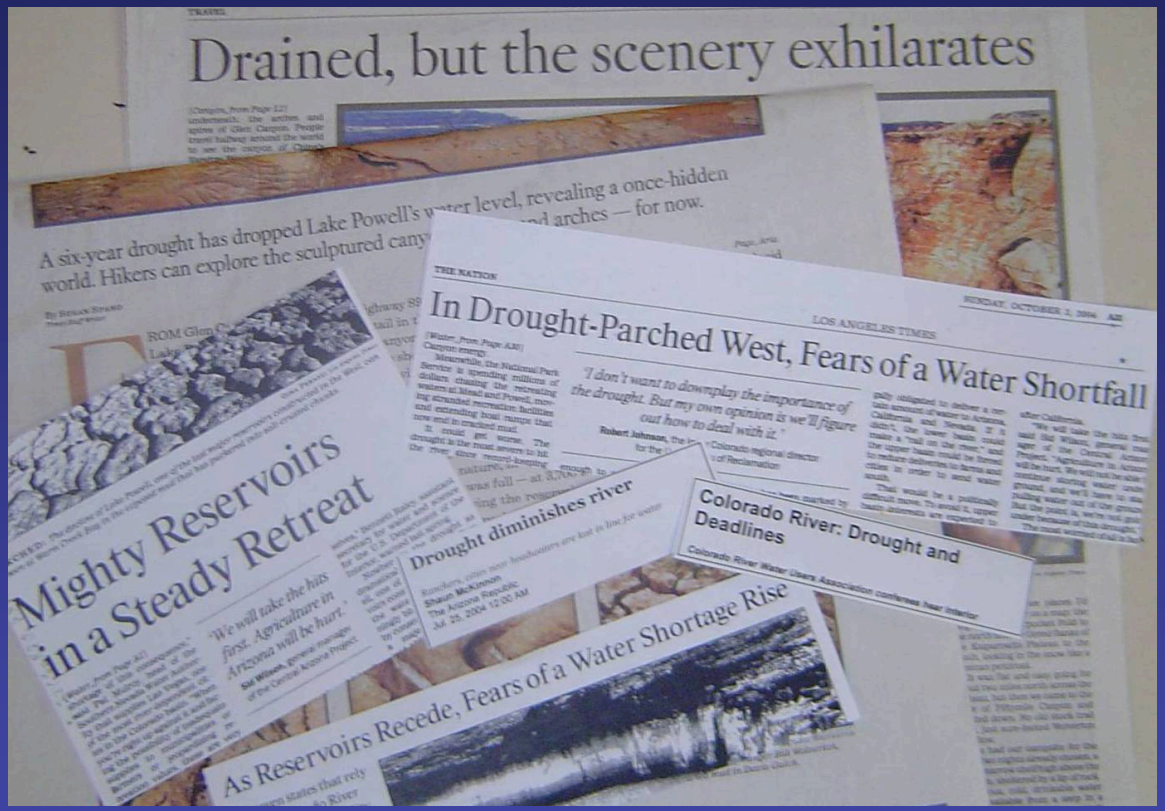
The Train Wreck(s)



- Short-Term problem is drought
- Long-Term problem is overuse

Drought!



Inflows

(% of normal):

1999-2000: 62

2000-2001: 59

2001-2002: 25

2002-2003: 52

2003-2004: 51

2004-2005: 109

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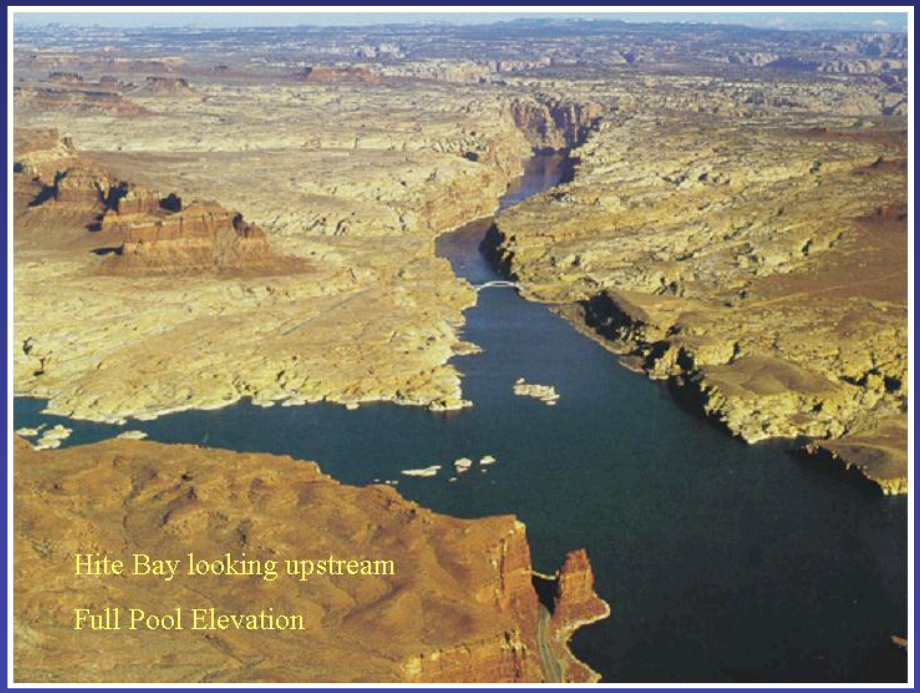
Lake Powell


Hite Bay looking upstream
Full Pool Elevation


Lake Powell
03/09/2003

Lake Mead

The Long-Term Problem

- In a normal water system:

  Average Yields > Firm Yield > Consumption

  Long-term average inflows

  Supplies that can be provided to users in severe drought

  Typical annual water uses throughout the basin (including reservoir evaporation and spills)

- In the Colorado River Basin (in MAF/yr.):

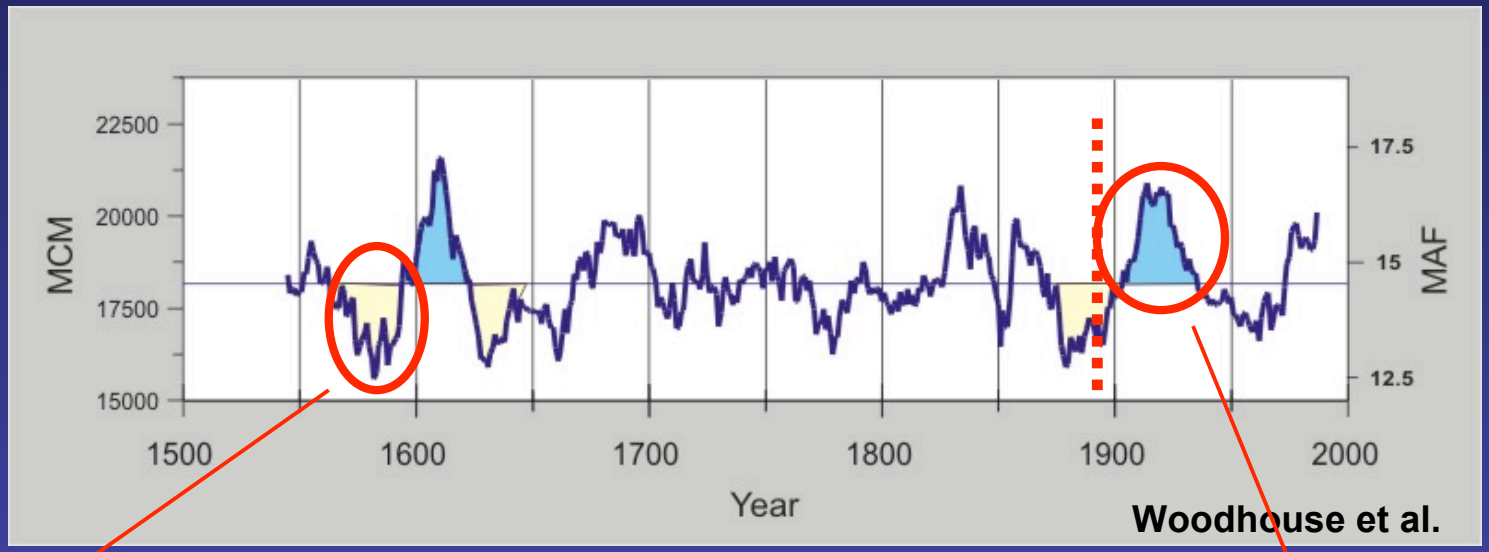
  Average Yields > Firm Yield < Consumption

  14.8 > ~13 max.?? < 15.4

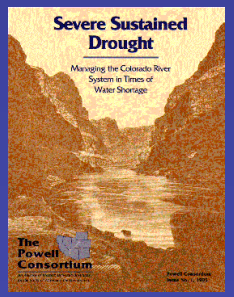
How Can Consumption Be Higher Than Average or Firm Yield?

- This is a relatively recent phenomenon (last 10 years) that occurred when demands quickly increased while an usually wet period in the 1980s ended
- Some of the demand has been met by drawing down reservoirs (nature is only partly to blame)

Many of the Basin's Problems Have Derived from a Poor Understanding of Average and Firm Yields



Period used by "Severe Sustained Drought" (SSD) study



Paleo research can be part of the solution

1922 Compact negotiated during the wettest 25 period in the last 500 years

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Some Lessons About Doing Applied Climate Research in the Colorado Basin

- There is a demand for better information and room for improvement
- The consequences of using incomplete information are appreciated (the compact example)
- Better information can improve system efficiencies (thereby reducing shortages) and can help illuminate management options. Some examples:
  - Better week 2 forecasts can reduce spills from small reservoirs
  - Better paleo reconstructions and/or long-term climate forecasts can inform scenario planning and reservoir operations models
  - Improved climate knowledge can influence ongoing multi-state negotiations regarding shortage sharing

This is a challenging basin to work in:

- Weak ENSO signal in many key sub-basins, weak PDO signal, no apparent AMO influence, snowline is not very temperature sensitive
- Paleo studies have not been entirely consistent and the climate change literature is thin

- The instrument record has real deficiencies
- Complex decision environment
- All science is politically sensitive in this basin

What Type of Climate Info is Needed?

- Climate "products" and more general education and knowledge/guidance
- The diversity of needs reflects the different time-scales of issues and decision-making, and the diversity among the decision-makers and decision-making forums

So what is WWA Doing?

Short Term Management Issues

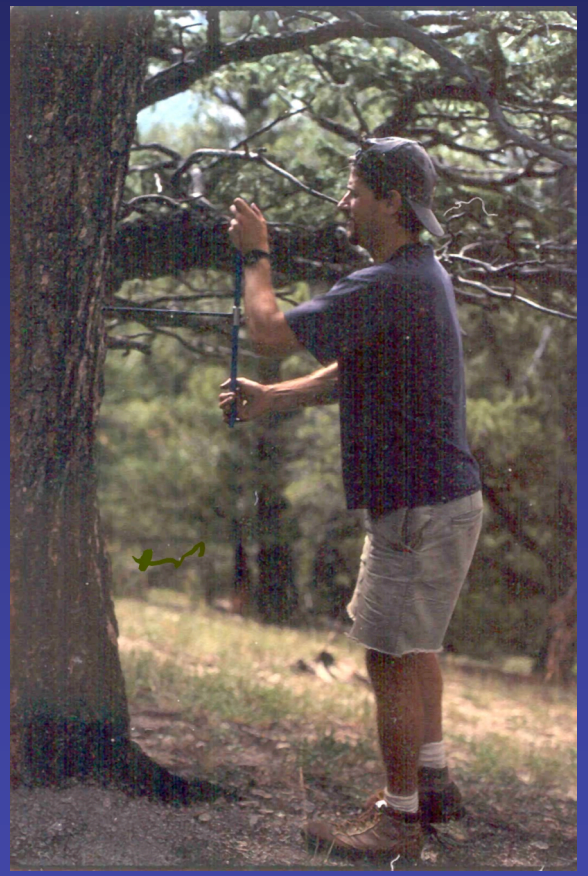
- Better utilize NOAA's MRF (medium range forecast) model to improve the Bureau of Reclamation's river management (up to week 2) and CBRFC's streamflow forecasts

Improve Our Understanding of How the System Responds to Sustained Drought

- SPRAT. Modeling how reduced Colorado River exports to the S. Platte influences water use and vulnerability
- SSD Redux. Assessing how the recent (ongoing) drought compares to the hypothetical drought considered in the SSD study (NOAA-HD)

Research with a Longer-Term Focus

- Growing interest in paleo research
  - Tucson meeting
  - Work with Denver Water
  - Offer to help Reclamation modeling
- ISSUE: How credible is this approach?
  - NRC panel (inspired by the Tucson meeting)
  - Can we convey skill?
  - Relevant in a changing climate?



Talking Climate Change

- WWA will participate in upcoming meetings in Las Vegas (SNWA) and Santa Fe (WEF)
- Subject covered in past WWA workshops and conferences:
  - *Water, Climate and Uncertainty* (2003)
  - *Hard Times on the* [illegible] *ver* (2005)

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General Educational Efforts

- Colorado River web site
  - Best online library available
  - http://wwa.colorado.edu/coloradoriver
- Speaking engagements
- WWA sponsored conferences
- Producing a primer on *Colorado River Climate and Hydrology* for California DWR
- *Intermountain Climate Summary*
- Participating in research consortiums:
  - Colorado River Delta Research Coordination Network
  - Powell Consortium (water center directors in the 7 basin states)

Water is for fighting. Take Home Lessons - 1

- Climate Variability and Climate Change 'Predictive' Signal Poor in Intermountain West but not useless
- Close Interaction with NOAA Labs (CDC) a bonus but also management challenge with two cultures ….
- Policy, Legal Issues Surrounding Water complicated here – flexibility exists within rules, especially during trying times…opt for win/win. Small changes produce criticality.
- Credibility with stakeholders critical; consistency, honesty, and humility
- WWA striving to seek a balance between product development and vulnerability assessments

Water Wars – more than a carnival game

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